# TITLE OF INVENTION

# Layered High Loft Flame Resistant Batting, Articles Containing Said Batting, and Processes for Making Same

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

This invention relates to a layered high loft flame resistant batting for use in fire-blocking an article such as a mattress and processes for making the batting and methods of fire-blocking articles. When burned mattress sets utilizing the high loft flame resistant batting of this invention have a peak heat release rate of less than 200 kilowatts within 30 minutes and a total heat release of less than 25 megajoules within 10 minutes when tested according to Technical Bulletin 603 of the State of California, as revised July 2003.

### 2. Description of Related Art

The State of California has led the drive to regulate and reduce the flammability of mattresses and mattress sets in an attempt to reduce the number of lives lost in household, hotel, and institutional fires. In particular, the Bureau of Home Furnishings and Thermal Insulation of the Department of Consumer Affairs of the State of California issued Technical Bulletin 603 "Requirements and Test Procedure for Resistance of a Residential Mattress/Box Spring Set to a Large Open-Flame" to quantify the flammability performance of mattress sets.

Mattresses normally contain a mattress core covered by cushioning material or batting that is in turn covered with an outer fabric ticking. Most cushioning material or batting is made from foam or fiber materials that will burn when exposed to an open flame. One useful method of fire blocking foam cushions, particularly airplane seats, is disclosed in United States Patent No. 4,750,443 to Blaustein, et al., wherein three to seven layers of flame resistant fabrics are used underneath the covering fabric of the seat to encase the foam. To the degree required per the aircraft seat flammability test method, these fire-blocked cushions withstand a flame jet

impinging on the cushion and prevent the entire cushion from being engulfed by the flame or continuing to burn after the flame jet is removed. When applied to mattresses, the use of multiple fire blocking layers underneath the ticking can add stiffness or restrain the give of the mattress core, affecting overall comfort. Even single layers of fire blocking fabrics can restrain batting materials and affect the cushioning of mattresses. Therefore, what is desired is a solution that does not require incorporating an additional fire blocking layer. In particular, what is desired is a batting material that can also function as a fire blocker for the mattress or upholstered article.

Fibers such as para-aramid fibers are very useful in flame retardant fabrics however these fibers have a natural gold color that is present in fabrics made from substantial amounts of those fibers. It is undesirable for the natural gold color of the para-aramid fabric to show through the outer ticking of mattresses, which are normally of a white or light or off-white color, or to show through the outer upholstery covering fabric of furniture. Therefore, what is needed is a high loft flame resistant batting that incorporates a heat resistant fiber wherein the color of that heat resistant fiber is masked by other fibers in the high loft flame resistant batting, while still meeting important flame resistant requirements.

PCT Publication WO 03/023108 discloses a nonwoven high loft flame barrier for use in mattresses and upholstered furniture. These barriers have very low density, ranging from 5 to 50 kilograms per cubic meter, most preferably 7.5 kilograms per cubic meter. The preferred nonwoven high loft flame barrier comprises a blend of fibers including fibers that are inherently fire resistant and resistant to shrinkage by direct flame, and fibers from polymers made with halogenated monomers.

United States Patent Nos. 6,132,476; 6,547,835, and 5,609,950 disclose fabric blends of inherently flame resistant fibers and cellulosic fibers having increased flame resistance; the fabric can contain an additional fire retardant that is added, for example, as an additive in a dyeing step. Because of the low content of inorganic material the flame

resistant cellulose fiber disclosed in these references does not retain an adequate percentage of its weight when exposed to high temperatures.

United States Patent Nos. 6,579,396 and 6,383,623 disclose a high temperature insulating material having a density of from 0.1 to 3.0 pounds/cubic foot made from non-thermoplastic fibers and thermoplastic binder materials. The binder materials completely melt, and the liquefied thermoplastic material, presumably under the influence of surface tension, collects at the points the non-thermoplastic fibers come together, forming nodes when cooled, in contrast to sheath-core binder fibers that can bind a number of fibers to the binder fiber along its length and that retains a core of thermoplastic material after heating.

United States Patent No 4,199,642 discloses an intimate blend of 80 to 98 percent polyester fiberfill and 2 to 20 percent synthetic organic filamentary material. The organic filamentary material can be poly(p-phenylene terephthalamide) or flame-retardant rayon.

United States Patent No 5,578,368 discloses a fire-resistant material comprising a fiberfill batt and at least one fire-resistant layer of aramid fibers.

## SUMMARY OF THE INVENTION

This invention relates to a high loft flame resistant batting and an article such as a mattress containing such batting; the batting comprising a base layer and a resilient layer, the base layer comprising 10 to 30 parts by weight heat resistant fibers, 35 to 55 parts by weight of a cellulose fiber that retains at least 10 percent of its fiber weight when heated in air to 700 C at a rate of 20 degrees C per minute, and 15 to 25 parts by weight binder material; the resilient layer comprising 0 to 50 parts by weight modacrylic fibers, 50 to 85 parts by weight polyester fiber, and 15 to 25 parts by weight binder material. The base layer comprises 20 to 70 parts by weight and the resilient layer comprises 80 to 30 parts by weight of the batting, based on the total weight of those two layers, and the batting has a total thickness of 1.25 centimeters (0.5 inches) or greater.

This invention also relates to a process for making a high loft flame resistant batting, comprising the steps of:

a) forming a base layer fiber mixture comprising 10 to 30 parts by weight heat resistant fibers, 35 to 55 parts by weight of a cellulose fiber that retains at least 10 percent of its fiber weight when heated in air to 700°C at a rate of 20 degrees C per minute, and 15 to 25 parts by weight binder fibers;

b) forming a resilient layer fiber mixture comprising 0 to 50 parts by weight modacrylic fibers, 50 to 85 parts by weight polyester fiber, and 15 to 25 parts by weight binder fibers;

c) forming a layered batt having a total thickness of at least 1.25 centimeters (0.5 inches) wherein one layer contains the base layer fiber mixture and another layer contains the resilient layer fiber mixture; and

d) heating the layered batt to activate the binder fibers and form a high loft batting.

Optionally, a portion of the high loft batting can be recycled into the base layer fiber mixture.

This invention further relates to a fire blocking quilt incorporating a layered high loft flame resistant batting and a method of fire blocking an article comprising the steps of:

a) combining a layer of a fabric ticking or upholstery, a high loft batting, and optionally a stitch backing layer, the high loft batting comprising

a base layer comprising 10 to 30 parts by weight heat resistant fibers,

35 to 55 parts by weight of a cellulose fiber that retains at least 10 percent of its fiber weight when heated in air to 700°C at a rate of 20 degrees C per minute, and 15 to 25 parts by weight binder material; and

a resilient layer comprising 0 to 50 parts by weight modacrylic fibers,

50 to 85 parts by weight polyester fiber, and 15 to 25 parts by weight binder material;

the base layer comprising 20 to 70 parts by weight and the resilient layer comprising 80 to 30 parts by weight of the batting, based on the total weight of those two layers, the batting having a total thickness of at least 1.25 centimeters (0.5 inches),

b) sewing the layers together to form a fire blocked quilt or upholstery fabric, and

c) incorporating the fire blocked quilt or upholstery fabric into the article.

## DETAILS OF THE INVENTION

This invention relates to a layered high loft flame resistant batting, and an article such as a mattress containing such batting. The batting comprises a base layer and a resilient layer that work together to form a fire blocking material. The base layer comprises 10 to 30 parts by weight heat resistant fibers, 35 to 55 parts by weight of a cellulose fiber that retains at least 10 percent of its fiber weight when heated in air to 700°C at a rate of 20 degrees C per minute, and 15 to 25 parts by weight binder material; the resilient layer comprises 0 to 50 parts by weight modacrylic fibers, 50 to 85 parts by weight polyester fiber, and 15 to 25 parts by weight binder material. In the layered high loft batting, the base layer is present in an amount of 20 to 70 parts by weight and the resilient layer is present in an amount of 80 to 30 parts by weight, based on the total weight of the base and resilient layers.

The high loft layered battings of this invention have a total thickness of 1.25 centimeters (0.5 inches) or greater. While there is no real limitation on how thick the batting can be, for many typical applications, the thickness of the high loft batting need not be higher than 7.6 cm (3 in), and for many mattress applications less than 5 cm (2 in) is very useful. The layered battings of this invention also have a preferred basis weight in the range of 8 to 12 ounces per square yard. The battings also have,

based on the total weight and thickness of the combined layers, a preferred composite density of 5.3 to 32 kilograms per cubic meter (0.33 to 2.0 pounds per cubic foot). Denser battings generally do not have the resiliency desired for use as cushioning in mattresses and other articles. Battings that are thinner or less dense than the desired ranges are not thought to provide the amount of cushioning desired.

The base layer of the layered high loft batting contains 10 to 30 parts by weight heat resistant fibers, 35 to 55 parts by weight of a cellulose fiber that retains at least 10 percent of its fiber weight when heated in air to 700°C at a rate of 20 degrees C per minute, and 15 to 25 parts by weight binder material. Preferably, the heat resistant fibers are present in the amount of 20 to 30 parts by weight, the cellulose fibers are present in the amount of 40 to 50 parts by weight. The base layer provides a dense structure that forms a char and maintains integrity in flame.

By "heat resistant fiber" it is meant that the fiber preferably retains 90 percent of its fiber weight when heated in air to 500°C at a rate of 20 degrees C per minute. Such fiber is normally flame resistant, meaning the fiber or a fabric made from the fiber has a Limiting Oxygen Index (LOI) such that the fiber or fabric will not support a flame in air, the preferred LOI range being about 26 and higher. The preferred fibers do not excessively shrink when exposed to a flame, that is, the length of the fiber will not significantly shorten when exposed to flame. Fabrics containing an organic fiber that retains 90 percent of its fiber weight when heated in air to 500°C at a rate of 20 degrees C per minute tend to have limited amount of cracks and openings when burned by an impinging flame, which is important to the fabric's performance as a fire blocker.

Heat resistant and stable fibers useful in the nonwoven fire-blocking fabric of this invention include fiber made from para-aramid, polybenzazole, polybenzimidazole, and polyimide polymer. The preferred heat resistant fiber is made from aramid polymer, especially para-aramid polymer.

As used herein, "aramid" is meant a polyamide wherein at least 85% of the amide (-CONH-) linkages are attached directly to two aromatic

rings. "Para-aramid" means the two rings or radicals are para oriented with respect to each other along the molecular chain. Additives can be used with the aramid. In fact, it has been found that up to as much as 10 percent, by weight, of other polymeric material can be blended with the aramid or that copolymers can be used having as much as 10 percent of other diamine substituted for the diamine of the aramid or as much as 10 percent of other diacid chloride substituted for the diacid chloride of the aramid. In the practice of this invention, the preferred para-aramid is poly(paraphenylene terephthalamide). Methods for making para-aramid fibers useful in this invention are generally disclosed in, for example, U.S. Patent Nos. 3,869,430, 3,869,429, and 3,767,756. Such aromatic polyamide organic fibers and various forms of these fibers are available from DuPont Company, Wilmington, Delaware under the trademark Kevlar® fibers.

Commercially available polybenzazole fibers useful in this invention include Zylon® PBO-AS (Poly(p-phenylene-2,6-benzobisoxazole) fiber, Zylon® PBO-HM (Poly(p-phenylene-2,6-benzobisoxazole)) fiber, available from Toyobo, Japan. Commercially available polybenzimidazole fibers useful in this invention include PBI® fiber available from Celanese Acetate LLC. Commercially available polyimide fibers useful in this invention include P-84® fiber available from LaPlace Chemical.

The base layer of the layered high loft batting also contains 35 to 55 parts by weight of a cellulose fiber that retains at least 10 percent of its fiber weight when heated in air to 700°C at a rate of 20 degrees C per minute. These fibers are said to be char forming. The cellulose fibers used in the composite of this invention are preferably regenerated cellulose fibers have 10 percent inorganic compounds incorporated into the fibers. Such fibers, and methods for making such fibers, are generally disclosed in United States Patent No. 3,565,749 and British Patent No. 1,064,271. A preferred char-forming regenerated cellulose fiber for this invention is a viscose fiber containing silicon dioxide in the form of a polysilicic acid with aluminum silicate sites. Such fibers, and methods for

making such fibers are generally disclosed in U.S. Pat. Nos 5,417,752 and PCT Pat. Appl. WO 9217629. Viscose fiber containing silicic acid and having approximately 31 (+/- 3) percent inorganic material is sold under the trademark Visil® by Sateri Oy Company of Finland.

The base layer of the layered high loft batting also contains 15 to 25 parts by weight binder material. The preferred binder material is a binder fiber that is activated by the application of heat. Such binder fibers are typically made from a thermoplastic material that flows at a temperature that is lower (i.e., has a softening point lower) than the softening point of any of the other staple fibers in the fiber blend. Sheath/core bicomponent fibers are preferred as binder fibers, especially bicomponent binder fibers having a core of polyester homopolymer and a sheath of copolyester that is a binder material, such as are commonly available from Unitika Co., Japan (e.g., sold under the trademark MELTY®). Useful types of binder fibers can include those made from polypropylene, polyethylene, or polyester polymers or copolymers, the fibers containing only that polymer or copolymer; or as a bicomponent fiber in side-by-side or sheath/core configuration.

The resilient layer of the layered high loft batting contains 0 to 50 parts by weight modacrylic fibers, 50 to 85 parts by weight polyester fiber, and 15 to 25 parts by weight binder material. The resilient layer preferably functions as the outer layer of the layered high loft batting, providing a resilient structure that sacrificially melts in flame and optionally, off-gasses to suppress flames. The resilient layer is typically white or light in color and also preferably shields any coloring of the base layer.

The resilient layer contains 50 to 85 parts by weight polyester fiber to provide resilience to layered batting. If more than 85 parts by weight polyester fibers are used, it is believed the batting becomes too flammable to be used in fire blockers. Polyester fibers are well known in the art and can be obtained from many sources. The preferred polyester fiber is made from poly(ethylene terephthalate) (PET)polymer. Other polyesters, however, may be used, such as homopolymers, copolymers, terpolymers, and blends etc., of polyester polymers and monomers of poly(propylene

terephthalate, poly(butylenes terephthalate), poly(1,4-cyclohexylene-dimethylene terephthalate) and copolymers and mixtures thereof. One type of PET fiber useful in this invention is commercially available from Invista, Inc. of Wilmington, Delaware under the trademark DACRON® Type 808 single hole hollow fiber having a linear density of 7.2 dtex/filament (6.5 denier/filament) having a cut length of 3.8 cm (1.5 in).

The resilient layer also contains 15 to 25 parts by weight binder material. As in the base layer, the preferred binder material is a binder fiber that is activated by the application of heat. Generally the same binder can be used for both the resilient and base layers, however, this is not a requirement.

The resilient layer optionally also contains 0 to 50 parts by weight modacrylic fibers. Modacrylic fiber is useful in this outer layer of the batting because this fiber releases flame-suppressing halogen-containing gases when burned. By modacrylic fiber it is meant acrylic synthetic fiber made from a polymer comprising acrylonitrile. Preferably the polymer is a copolymer comprising 30 to 70 weight percent of an acrylonitrile and 70 to 30 weight percent of a halogen-containing vinyl monomer. The halogen-containing vinyl monomer is at least one monomer selected, for example, from vinyl chloride, vinylidene chloride, vinyl bromide, vinylidene bromide, etc. Examples of copolymerizable vinyl monomers are acrylic acid, methacrylic acid, salts or esters of such acids, acrylamide, methylacrylamide, vinyl acetate, etc.

The preferred modacrylic fibers used in this invention are copolymers of acrylonitrile combined with vinylidene chloride, the copolymer having in addition an antimony oxide or antimony oxides for improved fire retardancy. Such useful modacrylic fibers include, but are not limited to, fibers disclosed in United States Patent No. 3,193,602 having 2 weight percent antimony trioxide, fibers disclosed in United States Patent No. 3, 748,302 made with various antimony oxides that are present in an amount of at least 2 weight percent and preferably not greater than 8 weight percent, and fibers disclosed in United States Patent Nos. 5,208,105 and 5,506,042 having 8 to 40 weight percent of an

antimony compound. The preferred modacrylic fiber is commercially available Protex C from Kaneka Corporation, Japan, which is said to contain 10 to 15 weight antimony oxides, although fibers having less antimony oxide, in the range of 6 weight percent or less, can also be used.

In the layered high loft batting, the base layer is present in an amount of 20 to 70 parts by weight and the resilient layer is present in an amount of 80 to 30 parts by weight, based on the total weight of the base and resilient layers. Preferably the base layer is present in an amount of 40 to 55 parts by weight and the resilient layer is present in an amount of 60 to 45 parts by weight.

This invention also relates to a process for making a high loft flame resistant batting, comprising the steps of:

a) forming a base layer fiber mixture comprising 10 to 30 parts by weight heat resistant fibers, 35 to 55 parts by weight of a cellulose fiber that retains at least 10 percent of its fiber weight when heated in air to 700°C at a rate of 20 degrees C per minute, and 15 to 25 parts by weight binder fibers;

b) forming a resilient layer fiber mixture comprising 0 to 50 parts by weight modacrylic fibers, 50 to 85 parts by weight polyester fiber, and 15 to 25 parts by weight binder fibers;

c) forming a layered batt having a total thickness of at least 1.25 centimeters (0.5 inches) wherein one layer contains the base layer fiber mixture and another layer contains the resilient layer fiber mixture; and

d) heating the layered batt to activate the binder fibers and form a high loft batting.

The fiber mixtures and layered batt may be formed by any method that can create low-density webs. For example, clumps of crimped staple fibers and binder fibers obtained from bales of fiber can opened by a device such as a picker. Preferably these fibers are staple fibers having a linear density of about 0.55 to about 110 dtex per filament (0.5 to 100

denier per filament), preferably 0.88 to 56 dtex/filament (0.8 to 50 denier/filament) with the linear density range of about 1 to 33 dtex/filament (0.9 to 30 denier/filament) being most preferred. The fibers generally have a cut length of about 1.3 cm to 10.2 cm (0.5 to 4 in) and a preferred crimp frequency of about 2.4 to 5.9 crimps per cm (6 to about 15 crimps/inch).

The opened fiber mixture can be then blended by any available method, such as air conveying, to form a more uniform mixture. Alternatively, the fibers can be blended to form a uniform mixture prior to fiber opening in the picker. The blend of fibers can then be converted into a fibrous web by use of a device such as a card, although other methods, such as air-laying of the fibers may be used. The fibrous web can then be sent via conveyor to a device such as a crosslapper to create a high loft crosslapped structure by layering individual webs on top of one another in a zig-zig structure. The rate of fiber opening and crosslapping is controlled to create high loft crosslapped structures of the desired height. Representative processes useful in achieving crosslapped structures, including processes for crosslapping an air-laid or otherwise formed web on a belt or apron, are well-known in the art and generally disclosed in United States Patent Numbers 3,558,029 to Manns; 3,877,628 to Asselin et al.; 4,984,772 to Freund; 6,195,844 to Jourde et al., and British Patent Number 1,527,230 to Jowett.

To create a multilayered high loft batting of this invention, two or more high loft structures having different compositions, preferably the compositions of the aforementioned base and resilient layers, can be made either simultaneously or sequentially and then overlaid, one on the other, on a conveyor or belt. This layered high loft web batting is then set by applying heat, preferably by use of a heated oven and preferably without compression of the batting, to activate the binder material. The high loft batting is then cooled to set the binder material.

In the preferred process, the edges of the layered high loft batting are then trimmed to provide a batting with a uniform width. The portion of the high loft batting trimmed is then recycled back into the process, preferably by processing this material through a picker, which separates

the trimmed edges into individual fibers. This recycled portion contains fibers from both the base and resilient layers, and therefore to maintain the color consistency of the resilient layer the recycled portion is preferably added to the base layer. However, since the base layer provides integrity to the layered batting in flame, and the recycled material contains flammable fibers, the amount of recycled material added to the base layer must be limited. Preferably, the total amount recycled to the base sheet is less than about 25 parts by weight of the total weight of the base sheet. Preferably, through this recycling process, the base layer can additionally contain polyester fiber in an amount up to 15 parts by weight and modacrylic fiber in an amount up to 5 parts by weight of the base layer.

This invention also includes a fire blocked article comprising the layered high loft batting described herein. Preferably, this article is a mattress comprising a quilt panel incorporating the high loft web batting of this invention. The mattress quilt panel can be formed by combining layers of ticking fabric, one or more layers of layered high loft batting of this invention, optionally foam, and if needed, a scrim backing, which is used on the side of the mattress quilt that will be facing the mattress internals.

The ticking fabric is normally a very durable woven or knit fabric utilizing any number of weaves, and tends to have basis weights in the range of 2 to 8 ounces per square yard (68 to 271 grams per square meter). Typical ticking fabrics may contain but are not limited to cotton, polyester fibers, or rayon fibers. The foam is typically a polyurethane foam. The scrim backing is generally a layer of a 0.5 - 1 oz/yd$^2$ nonwoven (generally spunbonded) fabric. The layers of the mattress quilt panel can be securely bound together by lines of stitching with thread.

The layered high loft batting of this invention can be incorporated mattresses, foundations, and/or box springs as a flame blocking layer. For example, the panels and the borders of mattresses, foundations, and/or box springs can utilize the previously described mattress panel quilt or any other variant that incorporates as a component the layered high loft batting of this invention. The stitching can be sewn with non-flame retardant

thread, however, a fire-retardant thread, such as one made from Kevlar® aramid fiber, is preferred for the stitching, especially for stitching of the borders of the mattresses, foundations, and/or box springs.

This invention further relates to a method of fire blocking an article, comprising the steps of:

a) combining a layer of a fabric ticking or upholstery, and a high loft batting, and optionally a stitch backing layer, the high loft batting comprising a base layer comprising 10 to 30 parts by weight heat resistant fibers, 35 to 55 parts by weight of a cellulose fiber that retains at least 10 percent of its fiber weight when heated in air to 700°C at a rate of 20 degrees C per minute, and 15 to 25 parts by weight binder material; and a resilient layer comprising 0 to 50 parts by weight modacrylic fibers, 50 to 85 parts by weight polyester fiber, and 15 to 25 parts by weight binder material; the base layer comprising 20 to 70 parts by weight and the resilient layer comprising 80 to 30 parts by weight of the batting, based on the total weight of those two layers, the batting having a total thickness of at least 1.25 centimeters (0.5 inches),

b) sewing the layers together to form a fire blocked quilt or upholstery fabric, and

c) incorporating the fire blocked quilt or upholstery fabric into the article.

## TEST METHODS

<u>ThermoGravametric Analysis</u>. The fibers used in this invention retain a portion of their fiber weight when heated to high temperature at a specific heating rate. This fiber weight was measured using a Model 2950 Thermogravimetric Analyzer (TGA) available from TA Instruments (a division of Waters Corporation) of Newark, Delaware. The TGA gives a scan of sample weight loss versus increasing temperature. Using the TA Universal Analysis program, percent weight loss can be measured at any

recorded temperature. The program profile consists of equilibrating the sample at 50 degrees C; ramping the temperature at from 10 or 20 degrees C per minute from 50 to 1000 degrees C; using air as the gas, supplied at 10 ml/minute; and using a 500 microliter ceramic cup (PN 952018.910) sample container.

The testing procedure is as follows. The TGA was programmed using the TGA screen on the TA Systems 2900 Controller. The sample ID was entered and the planned temperature ramp program of 20 degrees per minute selected. The empty sample cup was tared using the tare function of the instrument. The fiber sample was cut into approximately 1/16" (0.16 cm) lengths and the sample pan was loosely filled with the sample. The sample weight should be in the range of 10 to 50 mg. The TGA has a balance therefore the exact weight does not have to be determined beforehand. None of the sample should be outside the pan. The filled sample pan was loaded onto the balance wire making sure the thermocouple is close to the top edge of the pan but not touching it. The furnace is raised over the pan and the TGA is started. Once the program is complete, the TGA will automatically lower the furnace, remove the sample pan, and go into a cool down mode. The TA Systems 2900 Universal Analysis program is then used to analyze and produce the TGA scan for percent weight loss over the range of temperatures.

<u>Thickness</u>. Thickness of the layered batting can be measured using ASTM D5736-95 (Reapproved 2001).

<u>Mattress Burn Performance</u>. The Bureau of Home Furnishings and Thermal Insulation of the Department of Consumer Affairs of the State of California (3485 Orange Grove Avenue, North Highlands, California 95660-5595, USA) published Technical Bulletin 603 "Requirements and Test Procedure for Resistance of a Residential Mattress/Box Spring Set to a Large Open-Flame" dated February 2003 to quantify the flammability performance of mattress sets. The bulletin was later revised in July 2003, requiring the limit of Peak Heat Release Rate (PHRR) to be less than 200

kilowatts and the Total Heat release limit at 10 minutes to be less than 25 megajoules. This protocol provides a means of determining the burning behavior of mattress/foundation sets by measuring specific fire test responses when the mattress plus foundation are exposed to a specified flaming ignition source under well-ventilated conditions. It is based on the National Institute of Standards and Technology Publication titled "Protocol of Testing Mattress/Foundation Sets Using a Pair of Gas Burners" dated February 2003.

Test data are obtained that describe the burning during and subsequent to the application of a specific pair of gas burners from the point of ignition until (1) all burning of the sleep set has stopped, (2) a period of 30 minutes has elapsed, or (3) flashover of the test room appears inevitable. The rate of heat release from the burning test specimen (the energy generated by the fire) is measured by oxygen consumption calorimetry. A discussion of the principles, limitations, and requisite instrumentation are found in ASTM E 1590 "Standard Test Method of Fire Testing of Mattresses". Terminology associated with the testing is defined in ASTM E 176 "Standard Terminology of Fire Standards".

In general, the test protocol utilizes a pair of propane burners, designed to mimic the heat flux levels and durations imposed on a mattress and foundation by burning bedclothes. The burners impose differing fluxes for differing times on the mattress top and the side of the mattress/foundation. During and subsequent to this exposure, measurements are made of the time-dependent heat release rate from the test specimen.

The mattress/foundation is placed on top of a short bed frame that sits on a catch surface. During the testing, the smoke plume is caught by a hood that is instrumented to measure heat release rate. For practicality, twin-sized mattresses and foundations are tested. After ignition by the burners, the specimen is allowed to burn freely under well-ventilated conditions.

The test specimen includes a mattress that is placed on foundation with T-shaped burners set to burn the specimen. One burner impinges flames on the top surface of the mattress and is set 39 mm from the surface of the mattress. The second burner impinges flames vertically on the side of the mattress/foundation combination and is set 42 mm from the side of the specimen. The side burner and the top burner are not set at the same place along the length of the specimen but are offset from on another along the length approximately 18 to 20 cm. The burners are specially constructed and aligned per the test method.

The test specimen is conditioned for 24 hours prior to the testing at an ambient temperature of above 12 Celsius (54 Fahrenheit) and a relative humidity of less than 70 percent. The test specimen of mattress and foundation is centered on each other and the frame and catch surface. If the mattress is 1 to 2 cm narrower than the foundation the mattress may be shifted until the sides of the mattress and foundation are aligned vertically. The burners are aligned and spaced from the specimen per the standard. Data recording and logging devices are turned on at least one minute prior to ignition. The burners are ignited and the top burner is allowed to burn for 70 seconds while the side burner is allowed to burn for 50 seconds (if possible) and then they are removed from the area. Data collection continues until all signs of burning and smoldering have ceased or until one hour has elapsed.

## EXAMPLE

A two-layered high loft batting having a base layer and a resilient layer was made, the fibers in both layers being held in place by use of a copolymer PET sheath/PET core binder fiber having a melting temperature of 120°C. Conventional carding lines/garnet machines and crosslappers were used to open and blend the fibers and form the individual high loft batting layers, which were combined together and heat set using a gas-fired oven. The high loft batting was then cooled. A portion of the high loft batting was recycled back into the cards and the fibers from this recycled portion became part of the base layer. The base

layer, excluding the recycled material, contained Type 970 Kevlar® aramid fiber (available from DuPont) having an individual filament denier of 2.2 dpf and an average 2" cut length, Type 33AP Visil® cellulose fiber (available from Sateri) having an individual filament denier of 3.5 dpf and an average 50 mm cut length, and the binder fiber (available from Nan Ya) having an individual filament denier of 4 dpf and an average cut length of 51 mm. The resilient layer had PET polyester fiber (available from KG) having an individual filament denier of 15 dpf and an average cut length of 64 mm, Protex C modacrylic fiber (available from Kaneka) having an individual filament denier of 7 dpf and an average cut length of 51 mm, and the same binder fiber as the base layer.

The test items, fiber blend ratio by weight, basis weight for base layer and top layer are all shown in the Table. The items had a thickness in the range of approximately 2.5 to 3.8 cm (1 to 1.5 in).

**TABLE**

| | Base Layer | | | | | Top Layer | | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | BW | Kevlar® | Visil | Binder | Recycle | BW | Modacrylic | PET | Binder |
| 1 | 5 osy | 30 | 50 | 20 | | 5 osy | 50 | 30 | 20 |
| 2 | 5 osy | 30 | 50 | 20 | | 7 osy | 50 | 30 | 20 |
| 3 | 5 osy | 20 | 40 | 20 | 20 | 5 osy | 20 | 60 | 20 |
| 4 | 4 osy | 20 | 40 | 20 | 20 | 5 osy | 20 | 60 | 20 |
| 5 | 4 osy | 20 | 40 | 20 | 20 | 5 osy | 0 | 80 | 20 |

Recycle composition- 20% binder, 15% Kevlar®, 25% Visil, 25% Modacrylic, 15% PET

The high loft battings were then tested for open flame test protocol TB 603 in single and double sided mattresses.

Four single-side mattresses were prepared for testing. Two of the mattresses incorporated Item #1 underneath the ticking on the top panel and two of the mattresses incorporated Item #3 underneath the ticking on the top panel. The mattress borders of all four mattresses utilized a fabric comprised of two spunlaced layers of fabric as a fire blocker; one

spunlaced layer had a basis weight of 2.5 oz/yd$^2$ and was comprised of a 50%/50% mixture of Kevlar® aramid fiber and Visil® cellulose fiber. The other spunlaced layer had a basis weight of 4.0 oz/yd$^2$ and was comprised of a 33%/67% mixture of Visil® fiber and Protex C modacrylic fiber. This same fire blocker was used in the borders of the foundation. The fire blocker used on the foundation panel was a single spunlaced layer having a basis weight of 4.0 oz/yd$^2$ and was comprised of a 25%/75% mixture of Kevlar® aramid fiber and Visil® cellulose fiber.

Four double-sided mattresses were also prepared for testing. T hey were prepared the same as the single-sided mattresses with the exceptions that Item #1 was incorporated into two of the mattresses and Item #4 was incorporated into two of the mattresses, and, since these were double-side mattresses, the high loft layered battings were incorporated into both panels of the mattresses. All other materials were the same.

When tested, all of the mattress sets had a peak heat release rate of less than 200 kilowatts within 30 minutes and a total heat release of less than 25 megajoules within 10 minutes when tested according to Technical Bulletin 603 of the State of California, as revised July 2003.